

Space Weather Technical Forecast

Issued on Saturday, 11 November 2023 at 13:25 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: G1 to G2 Minor to Moderate geomagnetic storm Expected over UTC weekend, Chance G3 Strong geomagnetic storm at peak. Active electron fluence Expected at GEO until this arrival.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with only C-class flares observed. The largest events were a C7.1 observed at 11/0359UTC and a C6.5 observed at 11/0916 UTC, both appear to have originated from AR3483 in the northwest quadrant.

Also of note was a long-period C2.8 around 10/1930UTC from a potentially complex sub-photosphere region encompassing AR3480, 84 and 85 to its immediate east. This flare was accompanied by a modest coronal dimming, and appears to have generated a Coronal Mass Ejection (CME). Initial analysis results suggest a possible Earth-directed CME arriving beyond the current forecast period (15 Nov), although further analysis is currently on-going to firm up on the details of this event. This source region is in the same vicinity as that which produced the Earth-directed full halo CME of 09 November, which currently dominates the forecast.

A filament eruption was observed to have lifted-off the northwest quadrant around 11/0600UTC, which was associated with coronal dimming and produced a CME seen in coronagraph imagery. This event is yet to be analysed for any potential Earth-directed component. No other Earth-directed CMEs have been observed in the past 24 hours.

There are currently five sunspot regions on the visible disc, which appear to clustered in the western solar hemisphere, especially in the southwest. The most dynamic and complex group remains AR3483 in the northwest quadrant, which consists of a couple of delta spots in both the leading and trailing portion of the group.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by ACE and DSCOVR, showed very different tendencies, but overall are felt to be reflective of the waning enhancement from a high speed stream associated with CH67/-.

With ACE measurements taken in preference, solar wind speeds fell from Strong to Elevated: in the 600s of km/s to around 500km/s at present, with a declining trend. Density was steady in single figures ppcc, while the total interplanetary magnetic field strength (Bt) was steady at or below 3nT, with a varying Bz component within +/-3nT. The phi angle remained predominantly negative (towards the Sun), with just a few brief variations.

The net result of the above solar wind measures was for provisionally Quiet to Unsettled geomagnetic indices, peaking at Kp '3o' in the 00-03UTC and 03-06UTC intervals.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux continued to decline to background levels.

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GOES16 high energy (greater than 2MeV) electron flux showed a diurnal oscillation mostly within High levels, peaking at 3910pfu at 10/1850 UTC. The associated 24-hour fluence gradually increased through the period, with the fluence observation at 11/0001UTC being 1.56e8 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity carries a daily Slight Chance of increasing to Moderate, although recent flare activity has been Low and is therefore perhaps the least noteworthy aspect of the forecast.

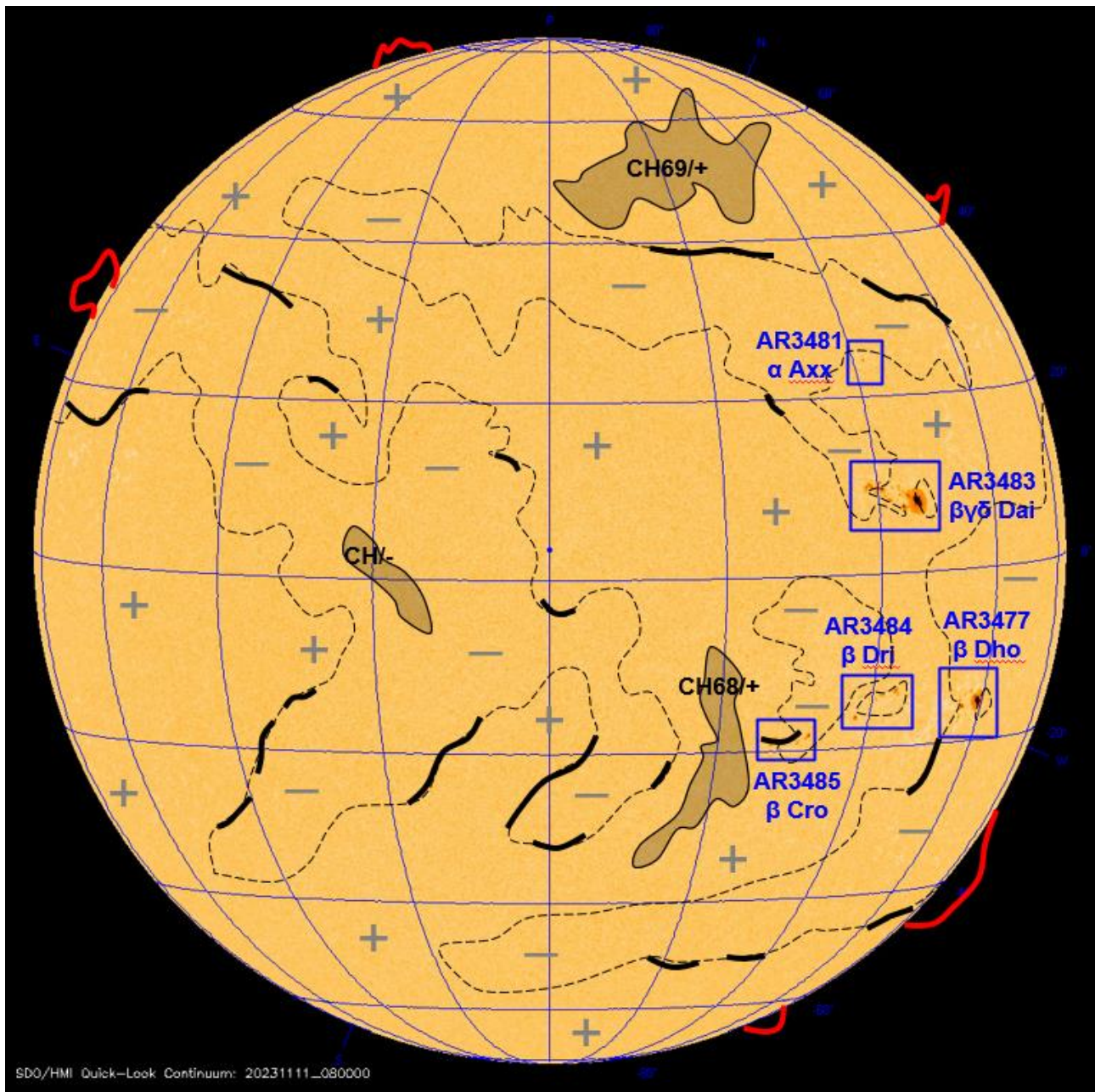
Solar Wind / Geomagnetic Activity: The geomagnetic forecast is dominated by the expected arrival of the 09 November full halo CME, currently forecast to arrive late in the current UTC day and into Day 2 (12/0001UTC). G1 to G2 Minor to Moderate geomagnetic storms are Expected at peak, with a Chance of G3 straddling the midnight separating both UTC days. Geomagnetic activity leading up to this event should be mostly Quiet.

One CME from the southwest quadrant 10/1930UTC has been preliminary analysed as a potential Earth-directed CME, which could arrive at Earth beyond this forecast period (probably on 15 Nov), although further analysis is currently on-going for this event.

Energetic Particles / Solar Radiation: There is a daily Slight Chance of S1 or greater should any of the western solar hemisphere sunspot groups produce significant flares in the period. This risk should begin to wane towards the middle of the coming UTC working week.

High energy electron flux (greater than 2MeV) is expected to continue near current levels at first but should be significantly attenuated at GEO upon the arrival of the 09 November CME, with a roughly even chance of Active fluence surviving into the start of the UTC day of Sunday 12 November. Once suppressed, there is a Chance of recovery at GEO as the new UTC week develops.

Figure 1. Solar Analysis Valid 11/0800 UTC.



Key: Filament — , Prominence — , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - γ - δ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

By far the most noteworthy aspect of the coming four-day period is the impending arrival of the 09 November C2 flare and major coronal dimming-associated full halo CME from near centre-disc. This feature inherently carries some uncertainty due to the very narrow perspective offered by STEREO and Lasco viewpoints, however arrival is mooted for the UTC overnight period Saturday 11 into Sunday 12 November. After numerous re-analyses, a most likely arrival has been set at 12/0001UTC. A G3 watch has been issued for this event starting 1200UTC on Saturday 11 November - lasting for 24 hours.

Separately from the above CME, the persistence forecast comprises largely Quiet geomagnetic conditions. Earth is expected to gradually exit the waning influence of CH67/-, prior to the CME's arrival, with Quiet to Unsettled activity predominant given the very modest IMF and despite the Elevated solar wind speed. Beyond this, current coronal holes are relatively ill-defined and given the high likelihood of transient effects, any fast wind(s) effects will be swamped and play a bit-part in the forecast.

All considered, initial Quiet to Unsettled conditions are Expected to give way to Minor to Moderate geomagnetic storms, with the peak likelihood around the turn of the UTC weekend days. There is a Chance of G3 Strong geomagnetic storms, and a Watch has accordingly been issued. Activity should wane from here, with a tail of G1 risk perhaps extending into the new working week, but an otherwise predominantly Quiet Monday and Tuesday are most likely. There is the potential for another Earth-directed CME to arrive just beyond this forecast period, with a preliminary forecast arrival of around 15-Nov, although this event is currently still being analysed to try and pin-down the detail and expected arrival time.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	70	90	20	1
Strong	G3	No	30	30	1	1
Severe	G4	No	5	5	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

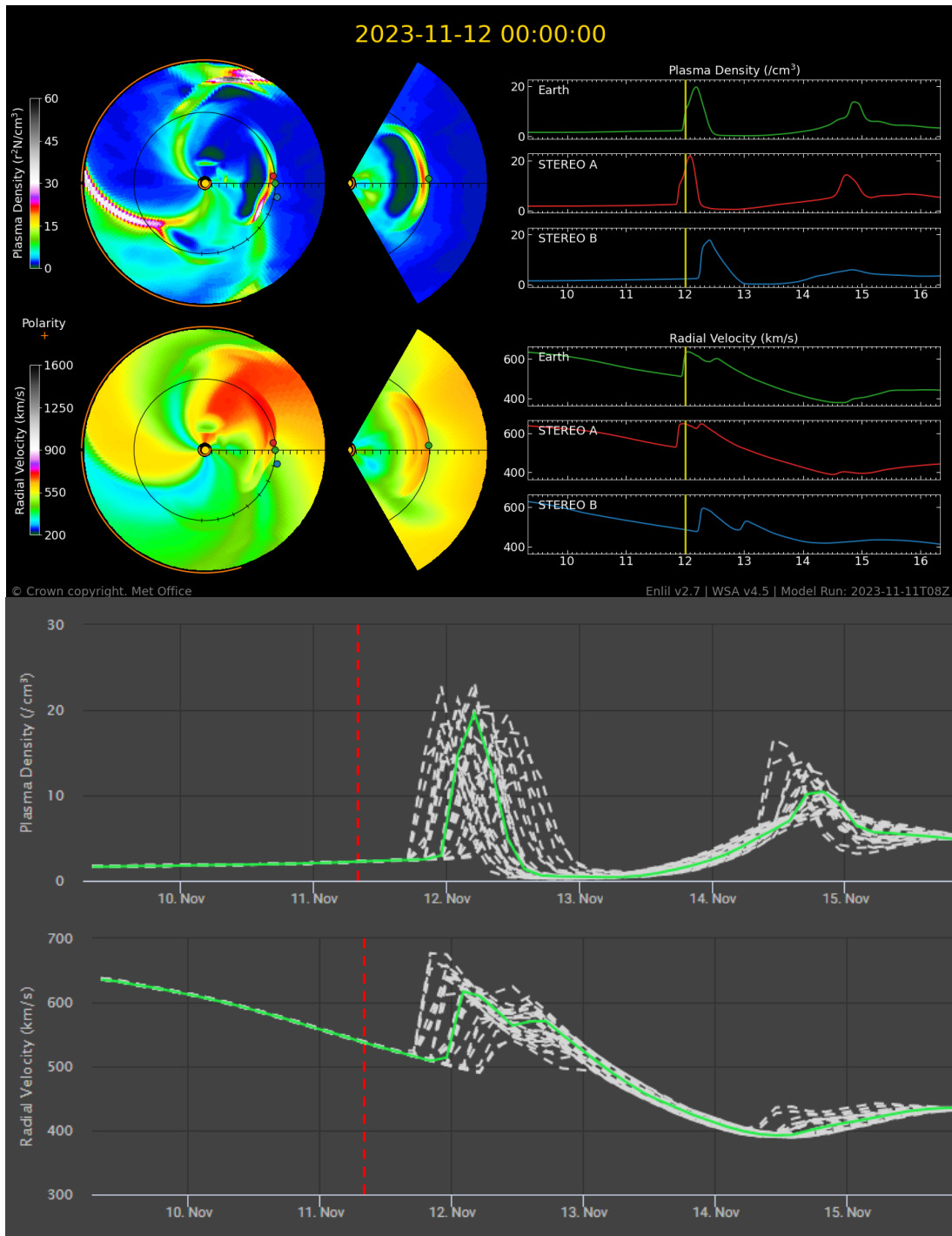
Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
19/1800UTC	Full	Vicinity of AR3480, 84 and 85. Possible filament.	Central SW	700 km/s	12/0001UTC	Earthdirected but cone and therefore speed low confidence.

Figure 2: Latest 11/0800URC MOSWOC Enlil model run and associated ensemble, which shows the 09 Nov CME arrival as most likely around the turn of the UTC day 11 Nov into 12 Nov. Also of note,

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the preliminary analysis of the CME from the 10/1930UTC filament lift-off from the southwest quadrant, which may arrive at Earth on the 15 Nov (beyond the current forecast period) – this event currently undergoing further analysis.



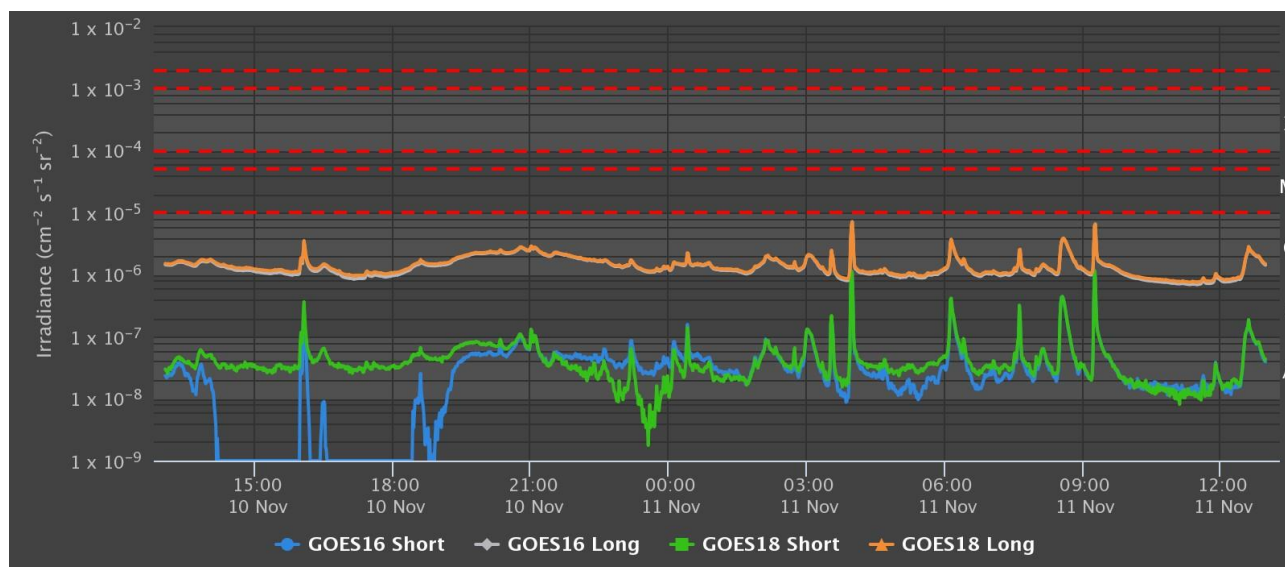
Radio Blackouts - X-Ray Flares:

There are currently five sunspot regions on the visible disc. AR3483 is the most dynamic and complex group on the solar disc at present. This region consists of two delta spots in both its leading and trailing portions of the group, giving a Dai/Beta-Gamma-Delta configuration. Perhaps more noteworthy is the cluster of groups in the southwest quadrant, which consists of AR3484 and AR3485, which are embedded within a large plage area and appear to be magnetically connected, with defuse portion of pores widely within this region. These may go some way to hinting at sources for recent CME activity here, even if accompanying flares have so far been much more modest.

In terms of the overall balance of front-side region populations, AR3477 should depart later on Tuesday 14 November to offer a slight downturn in M-class flare risk, with soundings, persistence and flux looping all suggesting limited contributions from any returning regions over the eastern limb.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	20	20	20	15
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 3: GOES X-flare flares.



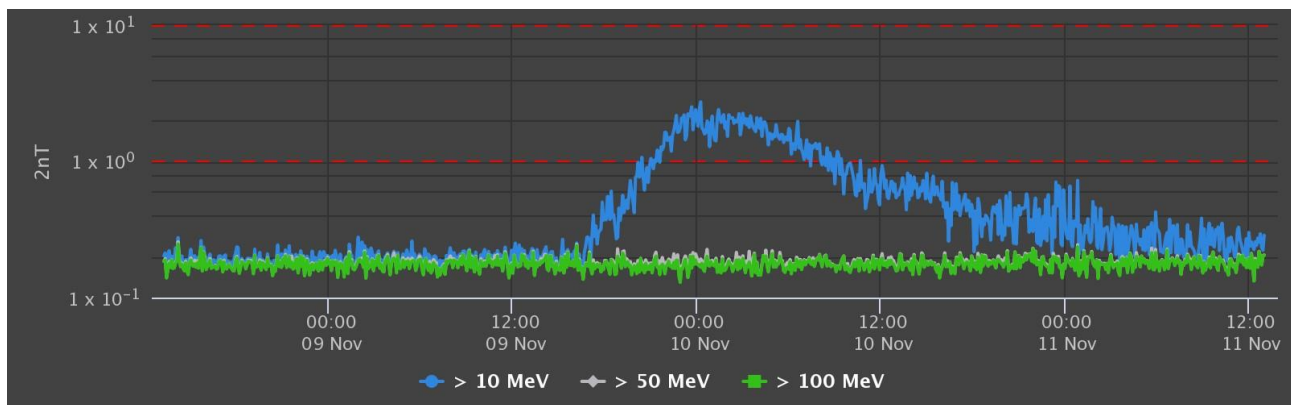
Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 has now returned to background levels. There is considered to be a Slight Chance of similar or greater given intervening rotation towards a geo-effective part of the Sun should similar events occur over the UTC weekend. The chances then begin to wane towards the middle of the coming UTC working week (i.e. just outside the current scope of the forecast) as the southwestern cluster of front-side sunspots begin to cross onto the far side.

Radiation Storms	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	No	10	10	10	10
Very Active	$\geq \text{S3}$ *	No	1	1	1	1

* S3 $\geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$. (pfu = $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)

Figure 4: GOES16 Proton Flux (past 72 hours) has declined to background levels after recent event associated with a long-period C2 flare.



High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy electron flux (greater than 2MeV) has shown day-on-day increases in response to the recent fast wind from CH67/-, but is expected to now be near its peak in a steady state between Moderate and High flux.

Active electron fluence is Expected on Saturday 11 November, with levels in the Van Allen belts then very likely to be attenuated upon the arrival of the 09 November CME, with fluence perhaps just surviving into Sunday 12 November before falling off sharply for a time. Geomagnetic activity should then hold levels at GEO for at least 24 hours before an uncertain degree of recovery into the new working week.

The new UTC week is unlikely to offer further significant charging of the belts, and should the CME prove dispersive in terms of GEO electron populations, any subsequent recovery is unlikely.

MOSWOC REFM is not felt to be a useful guide in this instance given the overwhelming reliance of the forecast on transient activity.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	99	50	10	30
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 5: GOES-16 Electron Flux (top) currently above the active threshold. REFM electron fluence (bottom) shows fluence is currently Active, although is not considered to be a useful guide in this instance due to the forecast on transient activity.

